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RESEARCH MEMORANDUM

TESTS OF THE LANDING ON WATER OF A MODEL OF A HIGH-SPEED AIRPLANE - LANGLEY TANK MODEL 229

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

TESTS OF THE LANDING ON WATER OF A MODEL OF A HIGH-SPEED AIRPLANE - LANGLEY TANK MODEL 229

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SUMMARY

An investigation was made at Langley tank no. 2 monorail of the landing on smooth water of a $\frac{1}{12}$-size dynamic model of a hypothetical jet- and rocket-propelled airplane designed to fly at transonic speeds. The model skipped out of the water and experienced maximum normal accelerations up to 7.4g and maximum longitudinal accelerations up to 4.5g. A slight modification which broke the transverse curvature of the rear of the fuselage bottom reduced the suction forces there, eliminated the resultant skipping, and reduced the maximum normal accelerations.

The test is part of an investigation of the feasibility of the operation from water of high-speed airplanes, and the results of this test form a basis for evaluating the improvements in hydrodynamic characteristics obtained by various types of modifications to the basic model.

INTRODUCTION

Contemporary airplanes designed to fly at transonic and supersonic speeds usually have very high landing speeds, caused by the use of high wing loadings, sweepback of the wing, thin airfoil sections, and flaps that are not of the extremely high-lift types. The landing gears of such airplanes not only add to the weight but must be completely retracted in flight, thereby occupying valuable space in an already crowded airplane. High landing speeds lead to the necessity for long, smooth runways and make more difficult the design of landing gears, wheels, and brakes. Similar disadvantages obtain during take-off. Preliminary consideration indicated that the majority of the disadvantages might be reduced or eliminated by the operation of high-speed airplanes from water instead of from land, and that the modifications necessary to assure satisfactory hydrodynamic performance could be of such a form as not to affect the aerodynamic performance appreciably.

To investigate the feasibility of the water-based operation of high-speed airplanes, a series of tests of a dynamically similar model of a hypothetical jet- and rocket-propelled transonic airplane is being made to observe the take-off and landing characteristics of the model and the effects of various types of modifications on these characteristics. All modifications under consideration are designed to be retractable or to have a minimum of air drag. The first part of the investigation is concerned with landing characteristics, which are considered to be of primary importance because, for many applications, the take-off might be made with the aid of a catapult or other means. The present paper considers only the landing in smooth water of the basic model and one modification. The landing characteristics of the basic model form a reference for evaluating the improvements obtained by the various types of modifications.

MODEL

The model, designated Langley tank model 229, was based on an existing airplane that is designed to fly at transonic speeds. The general arrangement of the model is shown in figure 1 and a photograph of it is shown as figure 2.

The suggested interior arrangement of the full-size airplane is shown in figure 3. As can be seen, the turbojet engine, together with its tail pipe and air-intake ducts, is mounted above the center line of the fuselage to prevent the entry of water. The rocket motor is placed below the turbojet tail pipe at the rear of the fuselage, because it was considered that the entry of water into it would not affect its operation.

Pertinent dimensions of the hypothetical airplane and the $\frac{1}{12}$-size model are given in the following table:

	Full size	Model
Wing span, feet	25	2.08
Wing area, square feet	175	1.215
Sweepback of wing 30-percent chord line, degrees	35	
Dihedral of wing chord plane, degrees	-3	
Wing incidence, degrees	3	
Fuselage length, feet	42.22	3.52
Maximum diameter of fuselage, feet	5.00	0.42
Longitudinal position of center of gravity		
Feet from nose	21.19	1.76
Percent M.A.C. projected parallel to fuselage reference line	18.6	
Vertical position of center of gravity		
Feet below fuselage reference line	0.43	0.036
Gross weight with full fuel tanks, pounds	13,140	7.61
Landing weight with 40 gallons of turbojet fuel left, pounds	8720	5.05
Moment of inertia in pitch, slug-feet^2	18,500	0.0749
Moment of inertia in roll, slug-feet^2	2440	0.00982
Moment of inertia in yaw, slug-feet^2	15,600	0.0629
Turbojet thrust, pounds	3000	1.74
With water injection (about)	3500	2.03
Rocket thrust, pounds	6000	3.475

Note: Moments of inertia are about the center of gravity and for the landing weight.

The model was constructed of balsa wood with points of high-stress concentrations reinforced with plywood and hardwood. The tail surfaces were covered with strong tissue paper.

To improve the landing characteristics of the basic model, the lower rear portion of the fuselage was modified slightly to flatten

and break the circular cross sections. The resulting form of the bottom was that of a small planing surface with 20° angle of dead rise emerging from the original fuselage. The keel line of this modification was tangent to the lower profile line of the fuselage about halfway between the tail and the trailing edge of the wing. Figure 4 shows a comparison between the original and the modified fuselage.

APPARATUS AND PROCEDURE

The tests were made at the Langley tank no. 2 monorail, an apparatus which provides a means for launching a model into the air at a preset attitude and distance above the water. The launching speed was determined by measuring the time required for the launching carriage to traverse a known distance during unaccelerated motion just prior to the release, and could be determined to ±0.1 foot per second.

Aerodynamic tests of the model were made to determine, for various attitudes and flap deflections, the landing speed and the elevator deflection required to maintain attitude. The results of these tests, shown in figure 5, showed that a stall landing would be made at an attitude of about 12°. An attitude of 8° was selected as typical of a faster landing.

The behavior of the model during landing and the length of the landing run were observed visually and recorded by a motion-picture camera at the side of the tank. Time-history records of accelerations parallel and perpendicular to the fuselage reference line were obtained by a small, spring-driven, recording accelerometer with an accuracy of $\pm\frac{1}{4}g$. The procedure used to obtain the accelerations in one direction during a run, and then to turn the accelerometer through 90° and repeat the run to get the accelerations in the other direction. The accelerations presented herein are those measured at a point $8\frac{1}{2}$ inches forward of the center of gravity and on the fuselage reference line. Positive senses of normal and longitudinal accelerations are upward and rearward, respectively.

All landings were made at the landing weight of 5.05 pounds, corresponding to 8720 pounds, full size. Most of the landings were made with a flap deflection of 20°. Flap deflection of 40° was used for several landings, but in this condition the model tended to roll and pitch in the air at high angles of attack.

RESULTS AND DISCUSSION

Landing of Basic Model

Sequence photographs of two typical landings of the basic model are shown as figures 6 and 7. A description of a typical landing follows: At the instant of landing, the rear of the fuselage hit the water and the model trimmed down a little. After running in the water for a short distance, the flow of water around the rear of the fuselage sucked it down into the water so that the model trimmed up rapidly and skipped out of the water. At the second contact with the water the model trimmed down, ran at that attitude for some distance, trimmed up and then down again. By this time the model had slowed down almost completely. At the end of the run, the model turned, usually to the right. The turn was sharp but not violent due to the low speed at which it occurred.

In about half of the landings, the rear of the fuselage touched the water lightly and briefly, making the model trim down slightly in the air. The remainder of the landing run then took place as previously described.

During the approach to some landings at high attitudes, the model rolled in the air so that one wing tip hit the water before any other part of the airplane. When this happened, there was no indication of yawing or pivoting around the wing tip. The tip was in contact with the water for a very short time only and the water forces on it rolled the model back until the wings were about level. The model then continued its landing in the usual manner. This indicates that the wing tip provided adequate planing lift for lateral stability without undesirably high resistance. Thus no tip floats or special planing surfaces at the wing tips need be used.

Typical time histories of normal and longitudinal accelerations experienced during landings are shown in figure 8, and a summary of accelerations and lengths of landing runs is given in table I. As can be seen, the maximum accelerations experienced were 7.4g in the normal direction and 4.5g in the longitudinal direction. The values of accelerations given in table I for any one landing are the peak accelerations obtained at various times during landing. The first peak of normal acceleration is associated with the period of the landing run just before and during the rapid trimming up preceding the skip of the model out of the water. The second peak of normal acceleration is experienced when the model again hits the water after the skip. The time scale of the accelerometer records varied somewhat, so precise correlation of the motion pictures and the time histories of accelerations was not possible. The normal accelerations

measured on the basic model are about the same as those obtained during landings of flying boats on rough water, but are greater than those obtained during landings of flying boats on smooth water or of landplanes landing on runways. The longitudinal accelerations obtained on the model are considerably greater than those obtained during landings of flying boats on smooth water, but are about the same as those obtained during ditchings of landplanes which are considered to have satisfactory ditching characteristics. The first peak of longitudinal acceleration is greater than the usual maximum acceleration experienced by carrier aircraft in arrested landings. The average longitudinal acceleration is about the same as that of usual arrested landings of carrier aircraft.

As the landing attitude increased, the height and violence of the skip decreased. Flap deflection had no apparent effects on the accelerations experienced during landings, but damage to the flaps was more likely to occur at the 40° flap deflection.

Landings of Modified Model

Sequence photographs of a typical landing of the model with the modified fuselage are given as figure 9, and time histories of normal acceleration and longitudinal acceleration are given as figure 10. A summary of the accelerations and lengths of landing runs observed during the tests are given in table II. The maximum accelerations experienced by the modified model were 5.6g normal and 3.6g longitudinal. The modification reduced the suction force at the rear of the fuselage and eliminated the resultant skipping of the model. The modification reduced the normal accelerations, but had less effect on the longitudinal accelerations.

The air drag added by the modification to the fuselage is probably negligible or very small because the sharp edges of the modification were designed to be parallel to the air flow. This air drag could be eliminated by using retractable breaker strips in place of the modification tested. Such breaker strips have been successfully used on the tail extensions of other models to break the upward flow of water and thus eliminate suction forces on the tail extensions.

CONCLUSIONS

The following conclusions were drawn from the results of landing tests in smooth water of a model of a hypothetical transonic airplane as originally designed and as modified by the addition of a planing surface at the rear of the fuselage:

1. The flow of water around the rear of the fuselage produced suction forces which increased the trim and caused the model to skip out of the water.

2. Flattening and breaking the circular transverse sections at the rear of the fuselage bottom reduced the suction at the rear of the fuselage and eliminated resultant skipping.

3. The maximum normal accelerations experienced during landings were 7.4g for the original model and 5.6g for the modified model.

4. The maximum longitudinal accelerations were 4.5g for the original model and 3.6g for the modified model.

5. No tip floats or auxiliary planing surfaces need be used to obtain adequate lateral stability during water landings.

Langley Memorial Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va.

TABLE I.- SUMMARY OF RESULTS OF LANDING TESTS OF BASIC MODEL

[redacted]

Flap deflection (deg)	Attitude (deg)	Speed mph full-size	Landing	Normal acceleration, g	Longitudinal acceleration, g	Length of run (fuselage lengths)
40	8	132	1		4.5, 2.2, 2.4	9
			2		3.8, 1.2	11
	12	119	3		3.2, 1.5, 2.0	11
			4		3.0, 1.2	10
			5	5.4, 1.6		13
			[a]6	6.8, 1.0, 1.8		11
			7	5.2, 1.4		13
	16	117	[b]8		4.2, 2.4	13
			[b]9		4.2, 1.8	11
20	8	141	10	4.2, 6.6		14
			11	5.0, 7.4		14
			12	5.0, 7.2		14
	12	124	13	6.0, 6.0		17
			14	5.2, 4.0		15
			15	6.0, 6.0		16
	14	122	16	5.2, 6.0		17
			17	6.0, 4.0		18

[a]Model rolled in air and landed on right wing tip.
[b]Model rolled in air and landed on left wing tip.

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TABLE II.- SUMMARY OF RESULTS OF LANDING TESTS OF MODEL

WITH MODIFIED FUSELAGE

[redacted]

Flap deflection (deg)	Attitude (deg)	Speed mph full-size	Landing	Normal acceleration, g	Longitudinal acceleration, g	Length of run (fuselage lengths)
40	12	119	1	4.6		13
	14	118	2	4.6		9
20	8	141	3		3.6, 1.8	13
			4		3.6, 1.4	14
			5	4.4, 3.0, 1.4		13
			6	4.6, 2.6		11
	12	124	7		3.6, 1.8	15
			8		3.0, 2.0	17
			9	4.6, 4.0		14
			10	4.8, 1.4, 3.0		13
	14	122	11		3.2, 1.8	13
			12	5.6, 2.0		11
			13	5.0, 1.4		11

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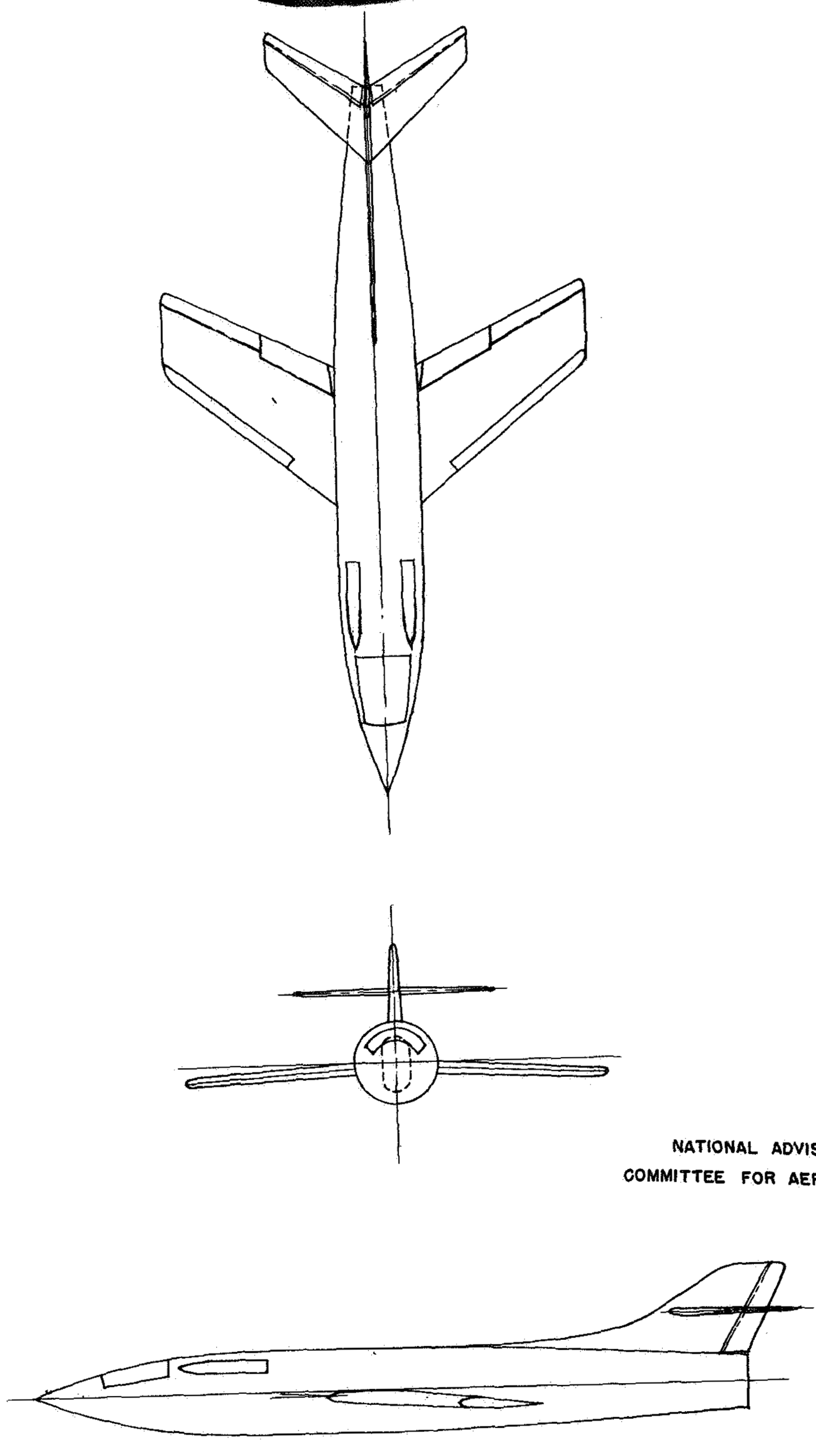

Figure 1.-General arrangement of model 229.

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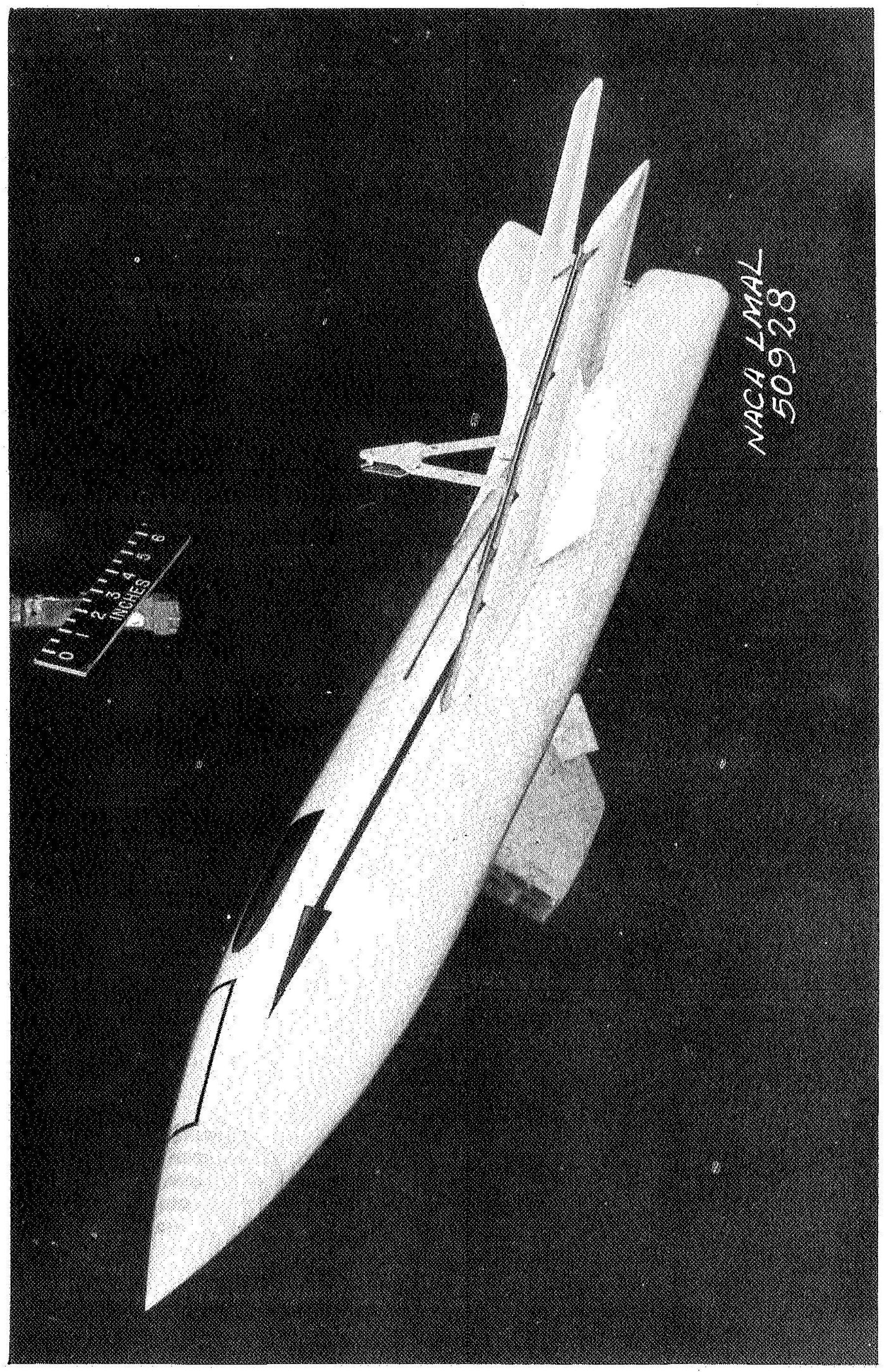

Figure 2.- Photograph of model 229.

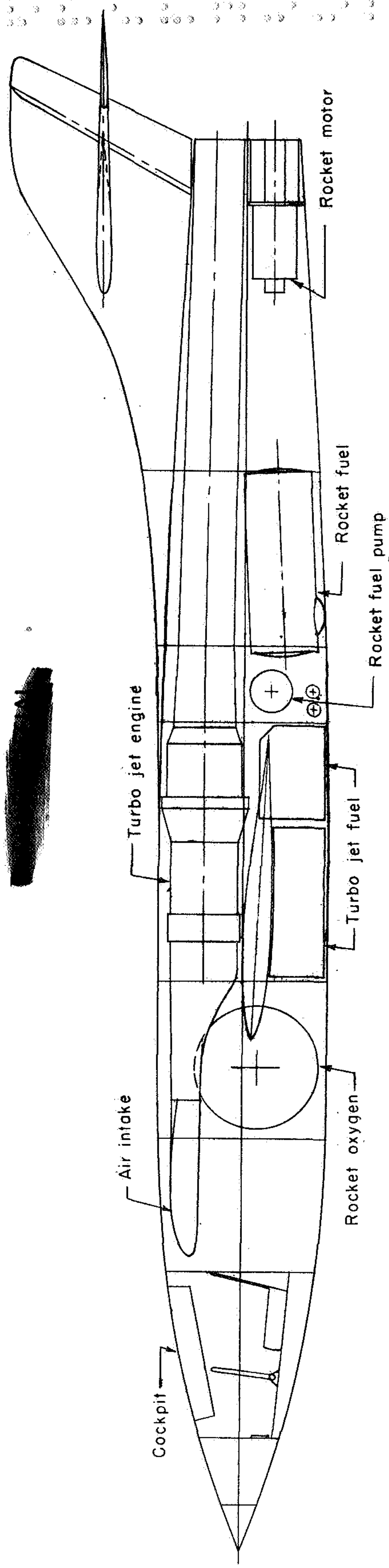

Figure 3.- Proposed inboard profile of high-speed airplane.

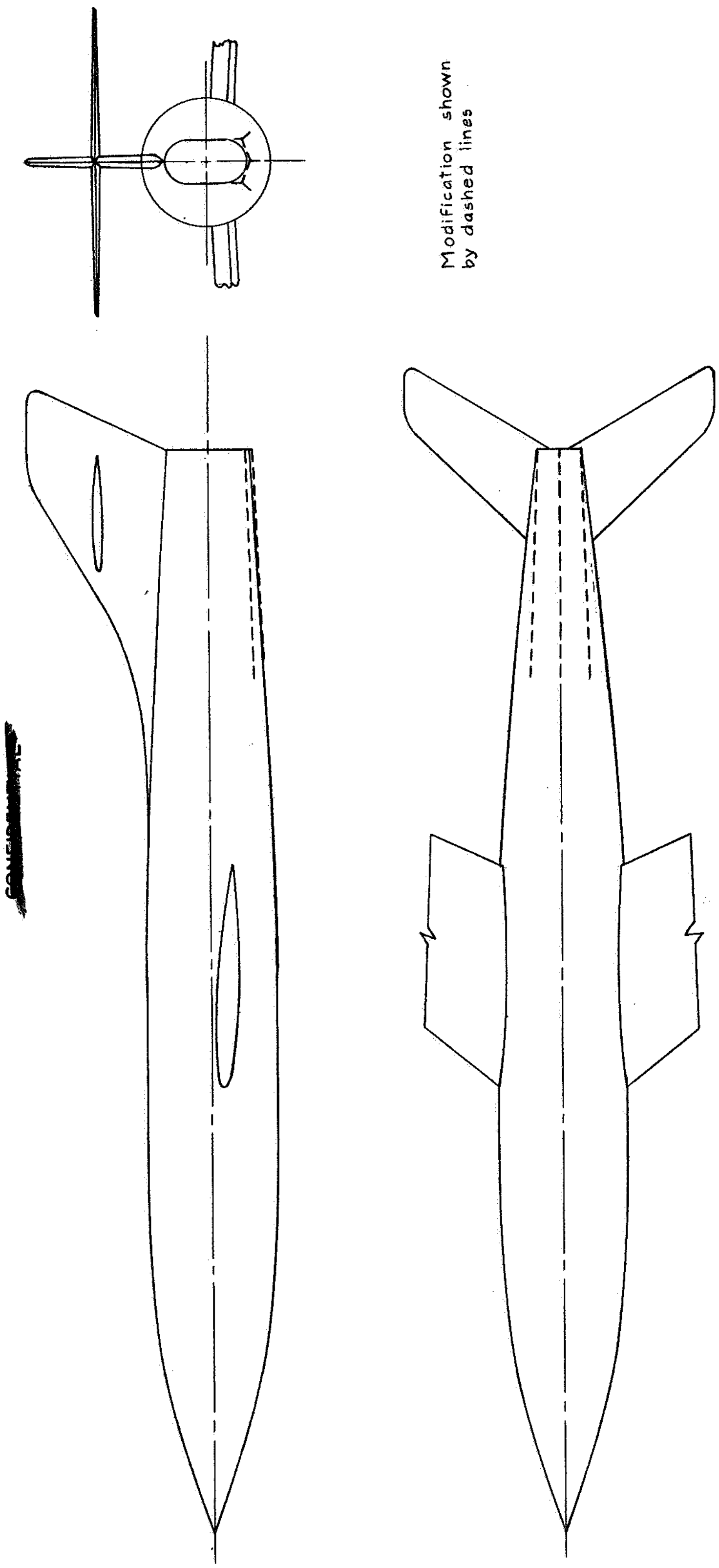

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Figure 4.- Model 229. Comparison between original and modified fuselages.

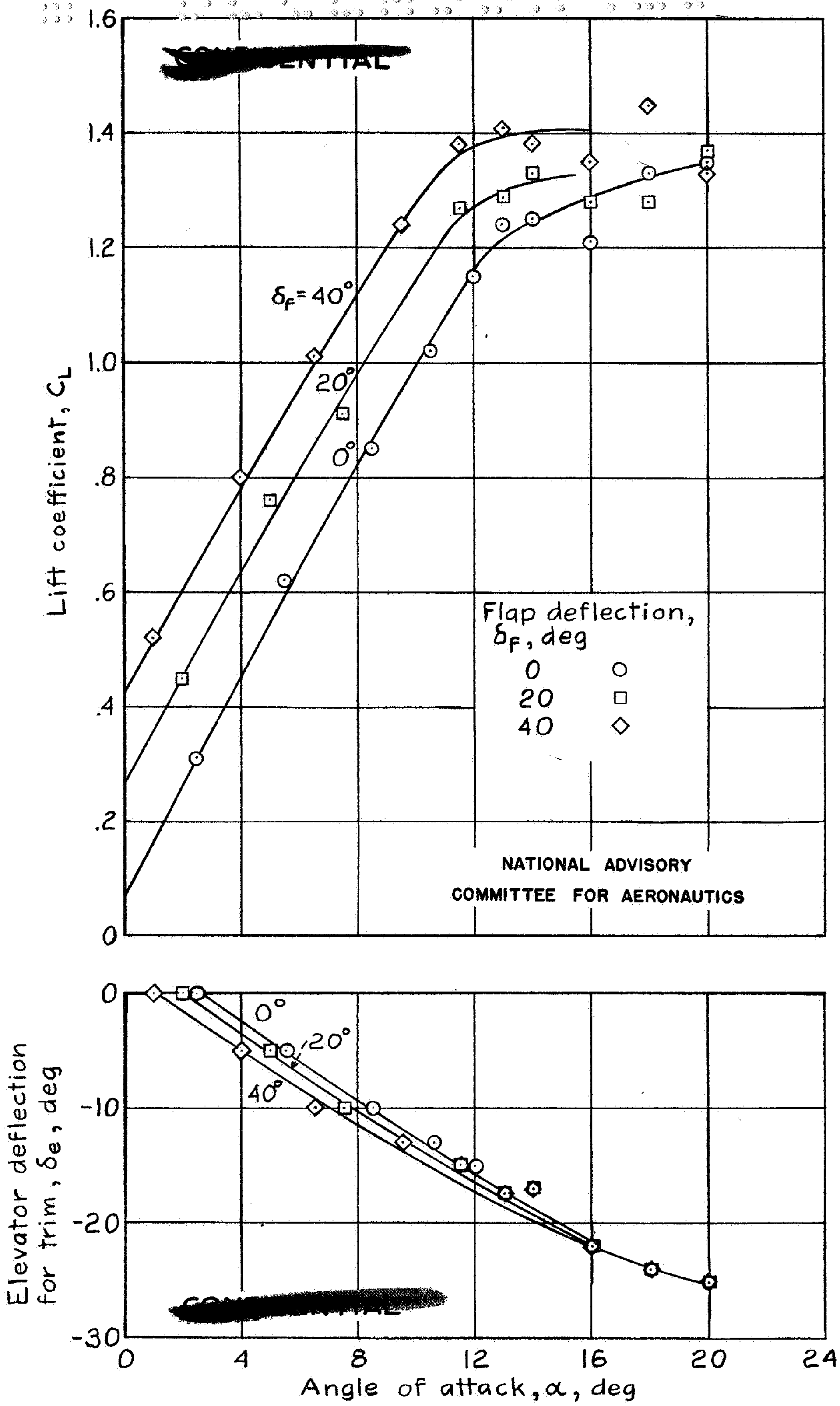

Figure 5.- Aerodynamic characteristics of model 229.

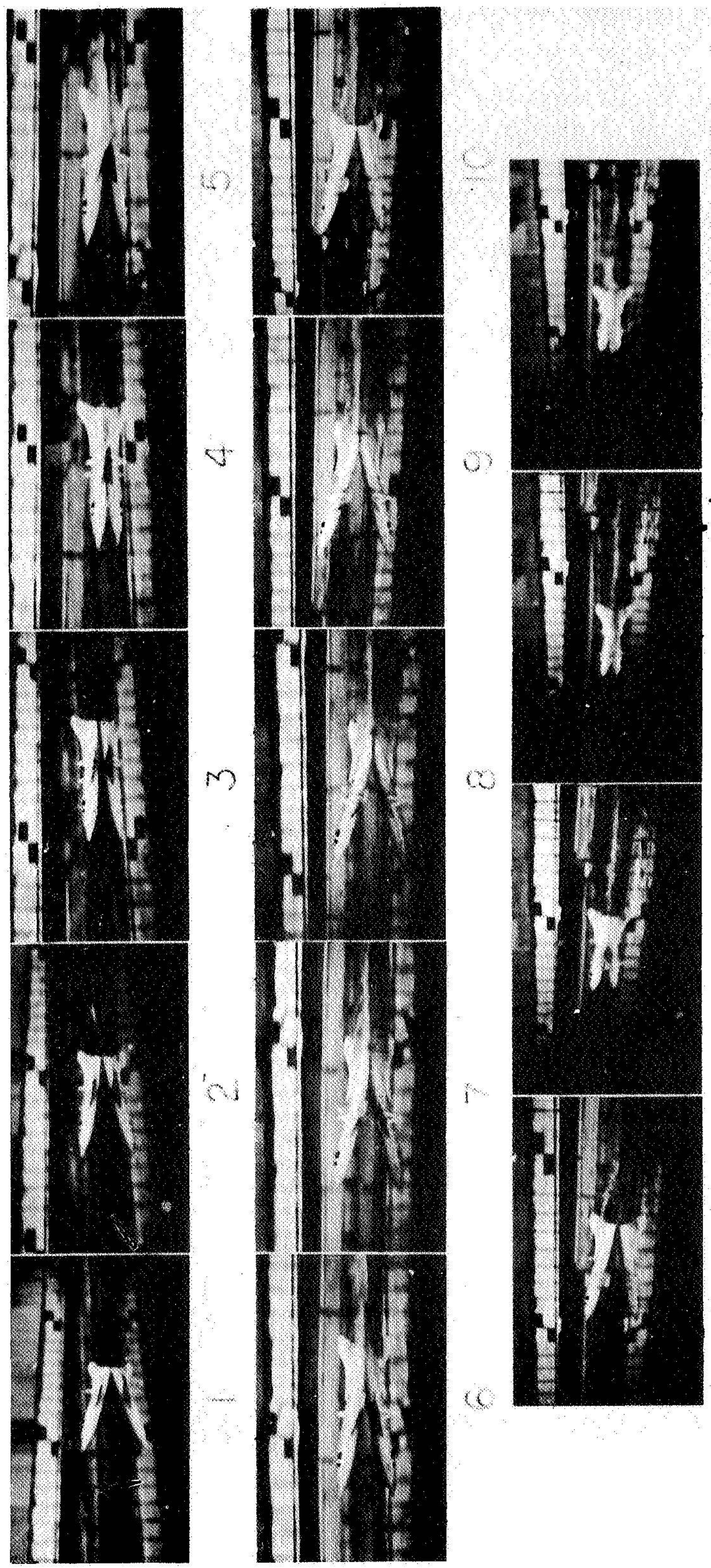

Figure 6.- Sequence photographs of landing of basic model at attitude of 12°. Time interval between pictures 0.22 second, full-size.

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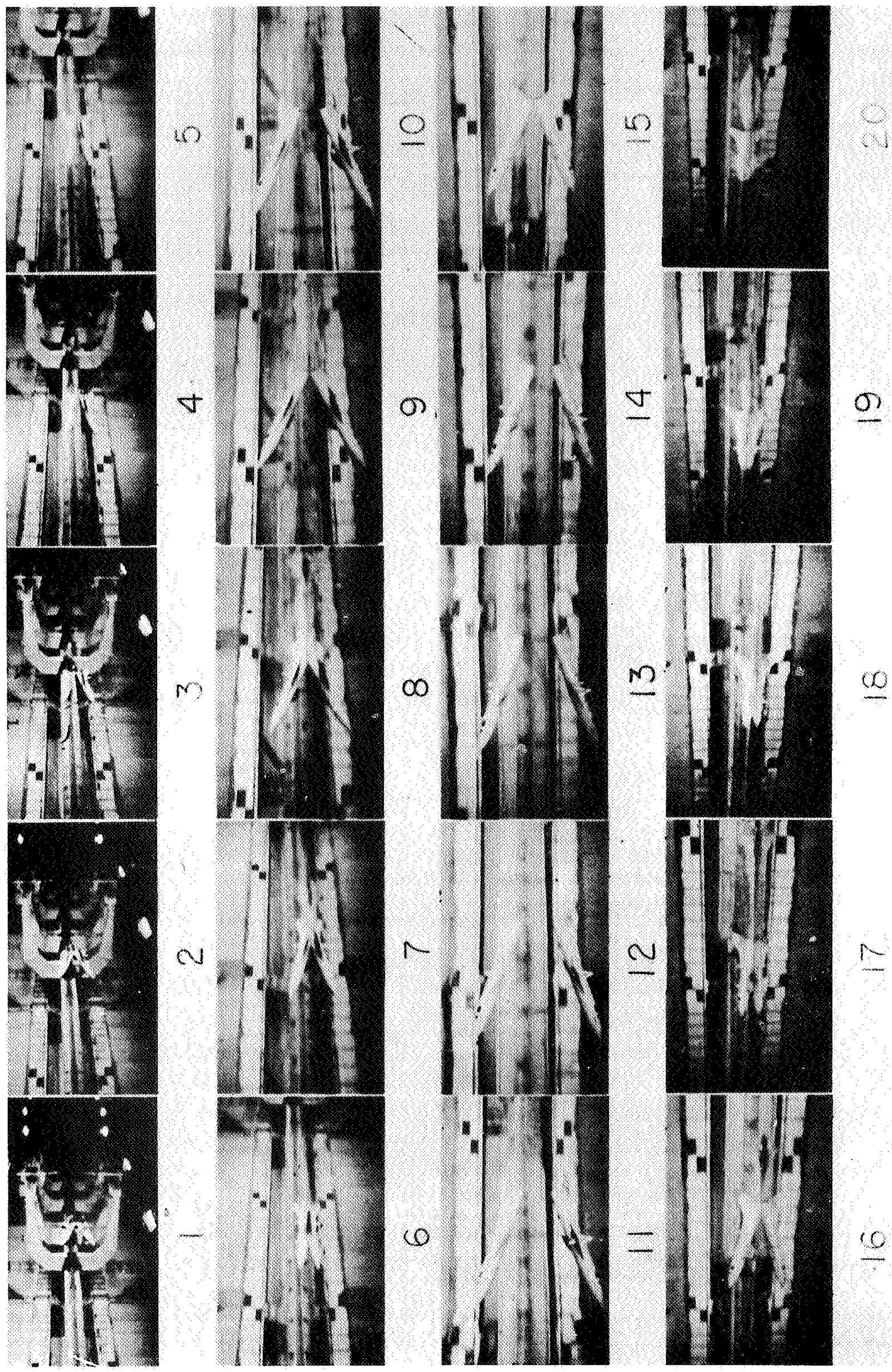

Figure 7.- Sequence photographs of landing of basic model at attitude of 8°. Time interval between pictures, 0.22 second, full-size.

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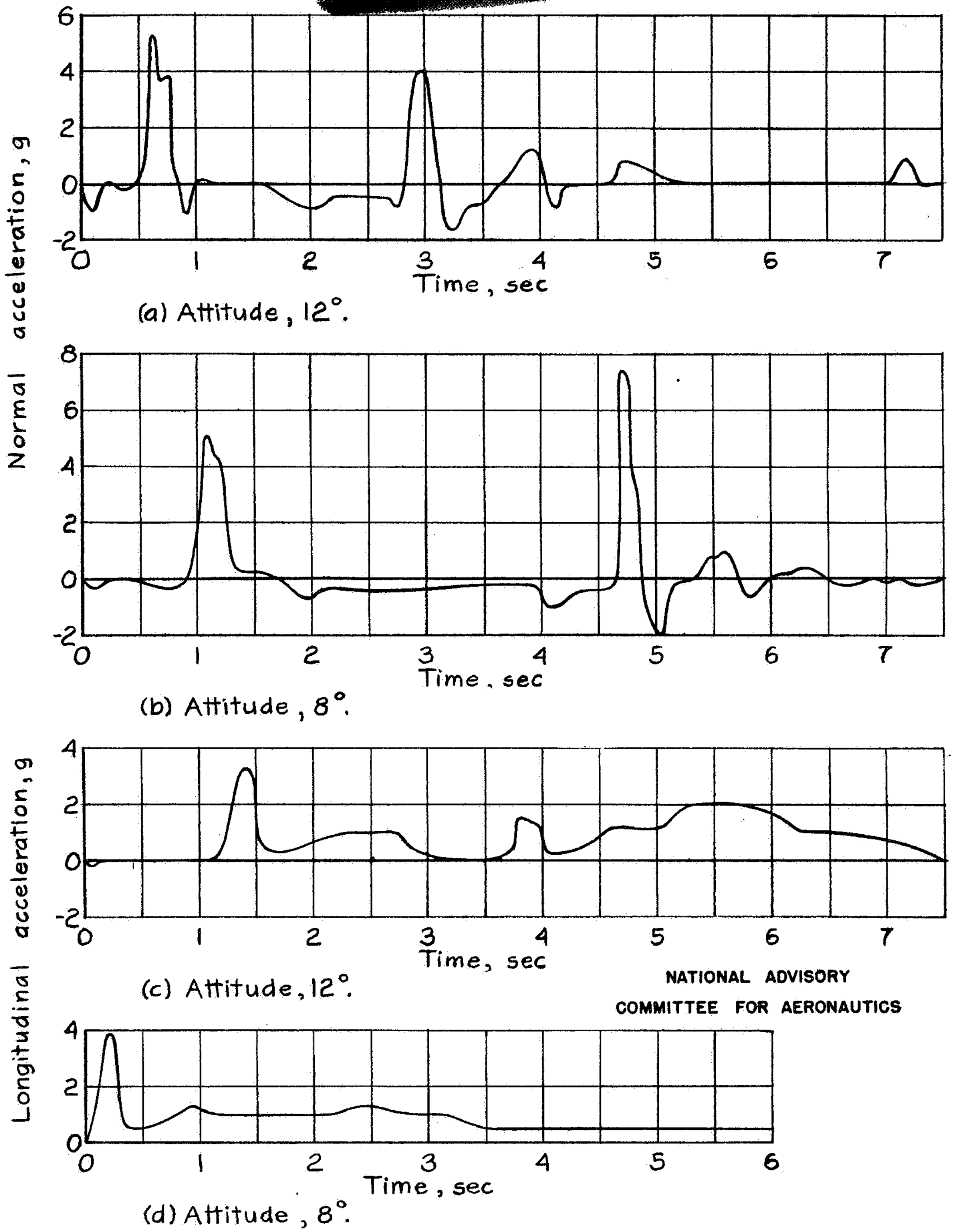

Figure 8.- Typical time histories of normal and longitudinal accelerations experienced during landings of basic model. (All values are full-size.)

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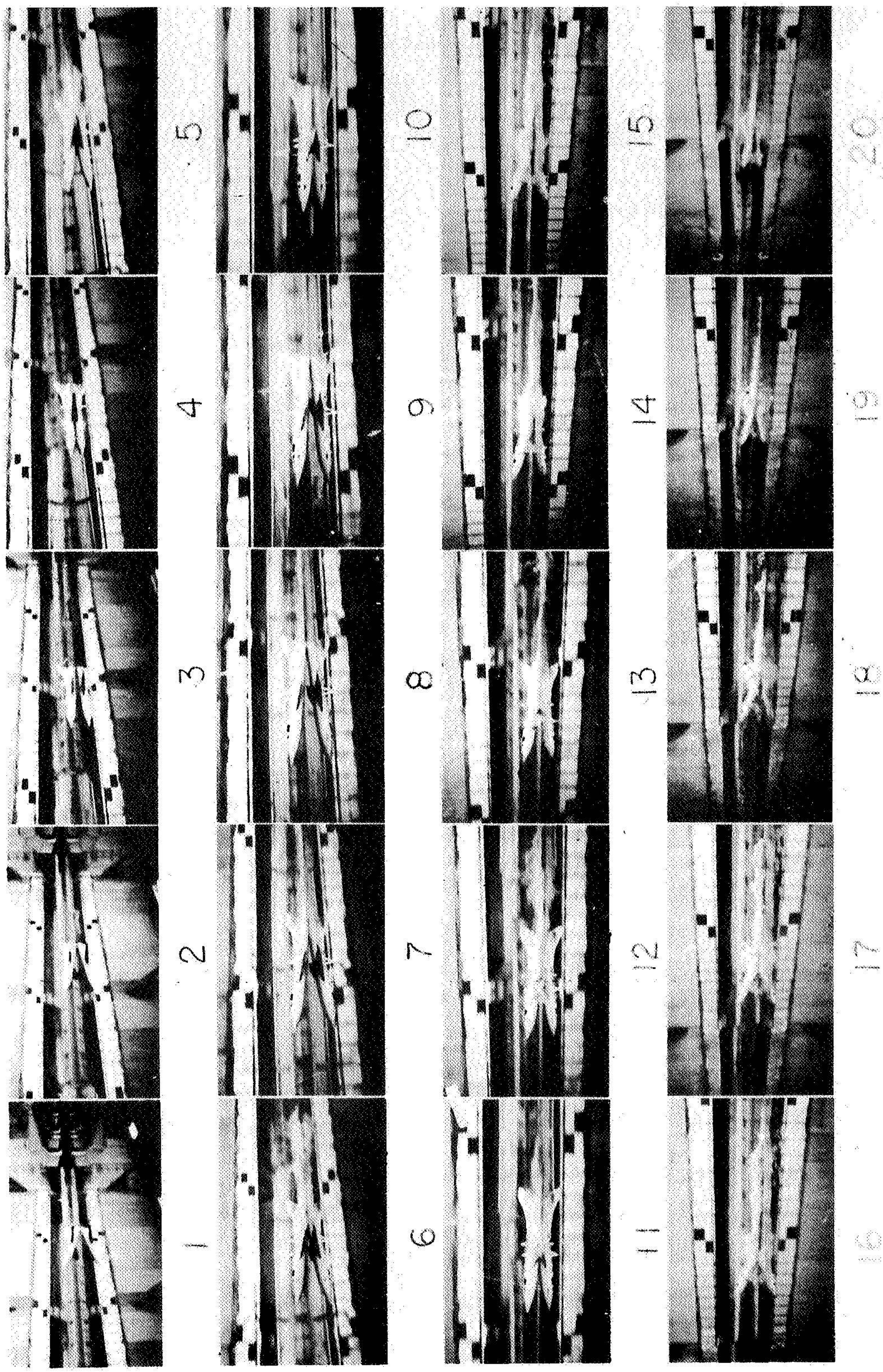

Figure 9.- Sequence photographs of landing of model with modified fuselage. Time interval between pictures, 0.22 second, full-size.

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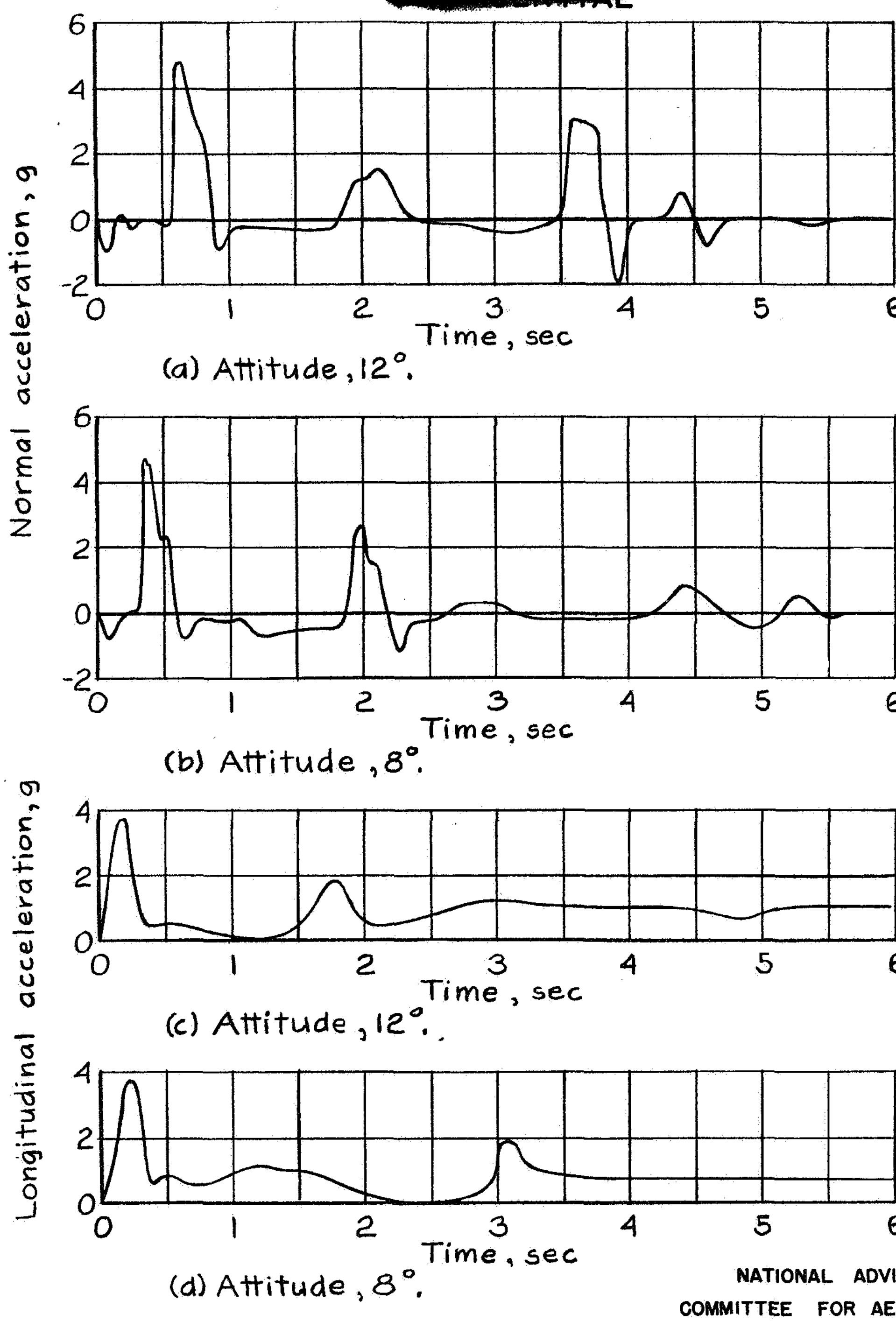

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Figure 10.- Typical time histories of normal and longitudinal accelerations experienced during landings of model with modified fuselage. (All values are full-size.)

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